Evaluation of Greenhouse Gas Emissions and Reduction Strategies Related to Waste Management by Local Government

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ABSTRACT

Greenhouse gas (GHG) emissions from community waste generation can represent a significant portion of a city, county, or region's GHG emissions inventory. Estimating a jurisdiction's emissions from this source can be challenging, since the waste generated by one community is sometimes exported to other communities for disposal. Current inventory protocols allow local governments to estimate waste emissions either based on the landfills they operate or based on the waste generated by the community regardless of where it is disposed. The more appropriate method for any given effort depends on the goals of the inventory and the data available. These emissions can then be reduced by reducing landfilled waste and/or by capturing landfill methane. Additional upstream GHG reductions can be attained through increased recycling, though these reductions cannot be applied toward a community's baseline emissions. There is growing interest in developing approaches for measuring, reporting, and reducing emissions associated with materials or goods produced, consumed, and disposed within given jurisdictions, and current protocols are certain to evolve.

INTRODUCTION

Greenhouse gas (GHG) emissions from community waste generation can represent a significant portion of a city or county's GHG emissions inventory, even though these emissions represent a smaller portion of national and state inventories. At the national scale, the U.S. Environmental Protection Agency (EPA) estimates that 2007 emissions from waste activities including landfills and composting operations were 132.9 Tg CO_2e and 3.5 Tg CO_2e, respectively.[1] These emissions are equivalent to approximately 2 percent of national GHG emissions. California Air Resources Board (CARB) estimates that landfills emitted approximately 5.6 million metric tons of carbon dioxide equivalent ($MMTCO_2$e), approximately 1 percent of California's 2002-2004 average inventory.[2]

This paper begins with an overview of the methods used and common issues encountered in conducting inventories of GHG emissions from waste generation. It then follows with a discussion of the policy framework in California, which will likely remain the most prominent legislative effort to reduce GHG emissions until a national policy is developed. Next, we discuss some local inventory efforts and the potential for identifying waste-related emission reduction opportunities. Finally, we discuss the role of life-cycle emissions reductions from waste management

BODY

Methodological Context

Existing guidance for states and local governments, such as the EPA State Inventory Tool and the ICLEI Local Government Operations Protocol encourage users to account for waste-related emissions within their operational control.[3] As such, state and local governments typically take responsibility for GHG emissions emanating from decomposing waste in landfills (so-called "waste-in-place"). In the case of states, state inventories capture emissions from landfills located within the state operating with state licenses. At the local level, inventories tend to include emissions from landfills operated by the local government. Local governments may instead include emissions associated with the solid waste generated by an entire community if the government anticipates addressing emissions associated with the community-wide solid waste in its GHG management plan; however, these calculations are much more uncertain and may lead to double counting. This is because waste generated in one locality is not necessarily disposed in waste disposal facilities inside the jurisdiction. Thus, the local government does not have control over the waste disposal method (i.e., incineration vs landfilling) or the control technologies in place to reduce GHG emissions (i.e., landfill gas flare, landfill gas to energy). If one local government estimates the methane emissions associated with landfilling waste generated by the local community as well as methane generated by landfills operated by the local government, the methane emissions from that waste may be double counted inside or outside the local boundaries, depending on how much of the waste is exported and how it is ultimately disposed.

Despite the difficulties of capturing all waste-related emissions associated with local government and community activities, waste mitigation actions offer great potential for local governments interested in reducing their GHG emissions. In comparison, local governments may have significantly more control over waste disposal practices than they do over other GHG-emitting sources, such as transportation and water use. In addition, studies have demonstrated the cost effectiveness of waste mitigation strategies in comparison to other GHG mitigation techniques.[4]

For the analysis in this paper, we used the Intergovernmental Panel on Climate Change (IPCC) methodology to estimate landfill emissions from waste disposed in Sacramento County.[5] The IPCC protocol uses a first order decay model to estimate GHG emissions from landfills. Methane emissions were calculated using a first order kinetics model. For a particular amount of waste-in-place (WIP) at a landfill, it is assumed that the waste was deposited in the landfill in equal installments for each of the years the landfill was open. Then the methane generated in the current year (before landfill gas recovery) can be estimated as:

(1) $\text{Methane} = (k*L_o*Rn*WIP*e^{-kA}-e^{-kB})/(e^{-k}-1)$

where:

- k = the exponential time constant of decay.
- L_o = methanogenic potential of the waste, expressed in cubic meters of methane per kg of waste
- WIP = total waste-in-place in the landfill in the inventory year, in Metric Tons
- R_n = a factor that incorporates the density of methane and any unit conversions required to balance the equation dimensionally
- A = the difference between the current year (plus one) and year the landfill was opened
- B = the difference between the current year (plus one) and the most recent year that waste was deposited in the landfill.

The k and L_o coefficients for this analysis were selected based on the EPA LandGEM model assumptions for the climatological conditions specific to the respective study areas. Landfill size and control technology were also taken into account in these calculations. CO_2e emissions were calculated by multiplying the methane emissions from landfills by the global warming potential (GWP) of methane of 21, as reported by the IPCC.[6]

Policy Framework in California for GHG Reductions

On September 27, 2006, the State of California passed the landmark climate change legislation titled the Global Warming Solutions Act of 2006, commonly referred to as AB-32. AB-32 requires that CARB adopt policies and regulations to ensure that statewide GHG emissions in the year 2020 are less or equal to the estimated statewide GHG emissions for the year 1990. AB-32 requires that CARB prepares a strategy document, referred to as the Scoping Plan, to specify the maximum technologically feasible and cost-effective ways to reduce GHG emissions by 2020.

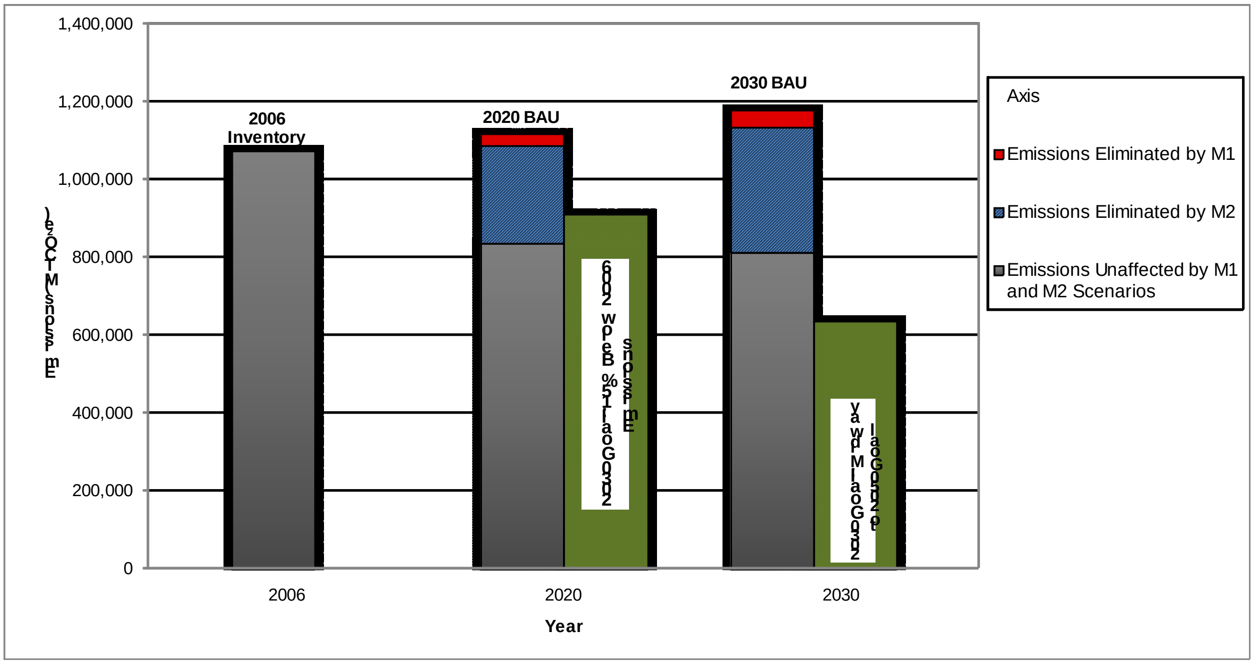
The Scoping Plan states that reducing *statewide* GHG emissions to 1990 levels means cutting approximately 30 percent from business-as-usual *statewide* emission levels projected for 2020, or about 15 percent from today's levels. In addition, the Scoping Plan states that a 30 percent reduction in California *statewide government-related* GHG emissions from 2020 business-as-usual (BAU) projections is approximately equal to a 15 percent reduction of current *statewide government-related* GHG emission levels. The Scoping Plan recommends that *local governments* ensure that their municipal and community-wide emissions match the State's reduction target by committing to a goal of 15% reduction of GHG emissions (based off the current year's emissions inventory) by the year 2020[7]. Although not explicitly stated in the Scoping Plan, recommending that local governments reduce existing GHG emission rates by 15% to achieve 2020 goals implies that local government GHG emission rates in the year 1990 were approximately 15% less than current emission rates.

Local governments can meet AB-32 goals for their internal operations by relying upon implementation of federal, state, regional, and other existing, proposed, and new GHG mitigation measures and regulations. Local jurisdictions can also reduce GHG emissions by implementing their own measures. For a given local jurisdiction, we organize these types of measures as follows:

- *Mitigation Scenario 1 (M1)* includes all adopted, implemented, and proposed federal, state, and regional measures that will result in GHG reductions for the jurisdiction and do not require the jurisdiction's direct action;
- *Mitigation Scenario 2 (M2)* includes measures currently implemented or in the process of implementation by the local jurisdiction, as well as new measures could be implemented by the local jurisdiction and that could further reduce the jurisdiction's operational GHG emissions. Mitigation Scenario 2 also includes federal, state, and regional measures that will result in GHG reductions for the jurisdiction and do require the jurisdiction's direct action.

Mitigation Scenario 1 measures may include requirements such as Title 24, Part 6, of the California Code of Regulations (Energy Efficiency Standards for Residential and Nonresidential Buildings), which will likely result in statewide reductions of GHG emissions but do not require action by local jurisdictions. Other statewide measures, however, may require action by local jurisdiction and these measures should be considered under Mitigation Scenario 2. For example, the CARB AB-32 Scoping Plan recommends three measures for reducing emissions from municipal solid waste at the state level that may require local waste control measures.[8] Figure 1 illustrates a theoretical emission reduction scenario, whereby Mitigation Scenarios 1 and 2 provide a framework for achieving the emission reductions from business-as-usual emissions needed to attain the AB-32 reduction goal in 2020. Figure 1 also shows a potential reduction goal for 2030, which is equivalent to midway between the 2020 goal and a 2050 goal of 80% below 1990 levels. By taking into account all emission reductions that would be achieved by federal, state, or regional action (i.e., Mitigation Scenario 1), this framework highlights the additional emission reductions that need to be addressed through action by the local jurisdiction to meet the goals of AB-32 (i.e., Mitigation Scenario 2). Since actions to reduce GHG emissions associated with municipal solid waste management largely rely on local action, given the general absence applicable national or statewide requirements, GHG emission reductions associated with this sector could contribute significantly to a local jurisdiction's achievement of AB-32 goals.

Figure 1. Theoretical reduction scenario from a local jurisdiction's "business as usual" emissions



Municipal Inventories and Waste Reduction

A GHG inventory includes the quantification of GHG emissions associated with an entity's products or services. The inventory can be used to identify opportunities for emission reductions associated with local government operation and serves as a baseline for evaluation of progress towards achieving emission reduction goals. If a local jurisdiction owns or operates landfills, these landfills can be a significant component of the local jurisdiction's GHG inventory. This is a result of the relatively high GWP of methane (21) and the fact that the landfills likely contain waste that has been generated by the entire population of the jurisdiction over a period of time. However, there is an opportunity for reduction of the waste-related emissions by recovering methane through landfill gas recovery and related electricity generation, and by reducing potential methane through reducing waste generated and diverting waste from landfills. Waste diversion programs that increase recycling or composting of waste can also result in additional upstream GHG benefits, though these upstream benefits do not affect the emissions within a jurisdiction's GHG inventory.

We have developed government and community-wide GHG emission inventories for 2005 for all of the cities in Sacramento County, as well as for the County itself. Waste emissions are a small fraction of overall County-wide emissions (~5 percent), but a larger fraction of the County government's inventory (15 percent). For the County government, landfill methane emissions were estimated using the waste-in-place method for waste accumulated in the County's two landfills over their lifetimes (one of these landfills is now closed). These emissions were adjusted to account for the County's methane control programs at these landfills. For the County's community-wide emissions inventory, by contrast, ICF estimated GHG emissions based on the total waste generated in 2005 in the entire County. Waste generation data was compiled from the California Integrated Waste Management Board's (CIWMB) web site.

ICF has also been working with the U.S. EPA to develop a methodology conducting regional GHG inventories. The methodology presents two options: one based on direct emissions from specific landfills, and another based on emissions from all waste generated in a community regardless of where the waste is disposed. In our work with the Delaware Valley Regional Planning Commission (DVRPC), ICF estimated landfill methane emissions based on the estimated waste generation. This option was chosen because the nine-county DVRPC region exports a large quantity of waste to landfills outside of the region. Ultimately, the goals of a given inventory effort will determine which method is more suitable.

Evaluation of Life-Cycle Emissions from Waste

The life-cycle emissions of waste include emissions associated with raw material acquisition, manufacturing, use, waste management, and transportation of raw and material waste. Many of these processes, particularly raw material acquisition and manufacturing, are not accounted for in municipal inventories since these emissions are typically outside of a local jurisdiction's operational control. However, a local jurisdiction's alternative waste management practices can result in significant reductions in these life-cycle emissions. To illustrate this reduction opportunity, we analyzed the life-cycle GHG reduction benefits (excluding emissions occurring during the use phase) of Los Angeles' goal to recycle or compost 70 percent of its solid waste by 2015. Under AB-939, the City is required to divert 50 percent of its solid waste from landfills. The current diversion rate at City facilities is estimated to be 62 percent, but increasing this diversion rate to 70 percent could result in additional GHG emissions reductions.

We used the EPA's Waste Reduction Model (WARM) to calculate the change in emissions due to increased diversion. WARM is used to calculate the GHG emission benefits and energy savings of alternative relative to baseline waste management practices—including source reduction, recycling, combustion, composting, and landfilling. ICF has supported EPA in developing and updating the life-cycle emission factors in WARM since 1993.

The disposal data presented in the City's waste characterization study were mapped onto the categories available in WARM.[9] All categories of disposed waste were then assigned a diversion strategy, indicating how the waste would be diverted from landfill: recycling for metals, plastics, paper products, and glass; composting for food scraps, yard trimmings, and other organic materials. Materials not included in WARM were left out of the analysis (e.g., hazardous waste). Using the City's waste characterization data and estimates on total volume, the annual volume of each type of material currently being deposited into landfills was estimated. We then developed a number of scenarios in which these waste streams were reduced as a result of increased recycling and composting. Taking into account existing landfill controls, we estimated that increasing Los Angeles' diversion rate from 62 percent to 70 percent for a single year would result in an estimated incremental GHG reduction of 1.1 $MMTCO_2e$ over a period of 30 years. However, it is important to note that the bulk of these reductions occur upstream and do not affect the City's baseline emissions.

CONCLUSIONS

There is growing interest among countries, states, and localities to develop approaches for measuring, reporting, and reducing emissions associated with materials or goods produced, consumed, and disposed within given jurisdictions. In current practice, inventory goals and data availability determine whether emissions are estimated based on specific landfills or a community's total waste generation. Regardless of inventory methodology, these emissions can be reduced by reducing landfilled waste and/or by capturing landfill methane. Additional upstream GHG reductions can be attained through increased recycling, though these reductions may not be applicable toward meeting reduction targets like those established under AB-32.

CARB, ICLEI, and the California Climate Action Registry (CCAR) plan to develop a GHG inventory protocol for local communities that incorporates the reporting of emissions related to the material supply chain. ICF will be supporting EPA over the coming year in working with the West Coast Climate Forum GHG Inventory Workgroup, ICLEI, CCAR, and CARB to develop guidance on including these emissions in this protocol. ICF is also supporting the U.S. EPA in developing the aforementioned regional GHG inventory methodology, which is currently under review. Standards in this area continue to evolve.

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KEY WORDS

Solid waste, greenhouse gas, local government, inventory